



Armed Forces College of Medicine AFCM



Nutritionally essential vitamins 1 (B2, B3 & B6)

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

- 1. Distinguish the active forms and functions of vitamins (B2, B3 & B6),**
- 2. Correlate vitamins (B2, B3 & B6) deficiencies to their clinical disorders**



Contents:



Riboflavin (vitamin B2)



Niacin (nicotinic acid)
(vitamin B3)



Pyridoxine (vitamin B6)

Vitamins



1. Vitamins are **organic nutrients** that are required to **small quantities** for a variety of biochemical functions.
2. They **cannot be synthesized** by the body in adequate amounts and must therefore be supplied i
3. They are **necessary to maintain good health**
4. Absence or relative **deficiency** of vitamins in diet leads to characteristic deficiency states and **diseases**.





Riboflavin (vitamin B2)

Case scenario



A male patient on **prolonged intravenous fluid** complaining of **red painful angle of the mouth**, **swollen fissured lips**, **sandy sensation** and **red coloration of eye**. Urine analysis revealed **low levels of Riboflavin vitamin (B2)**.

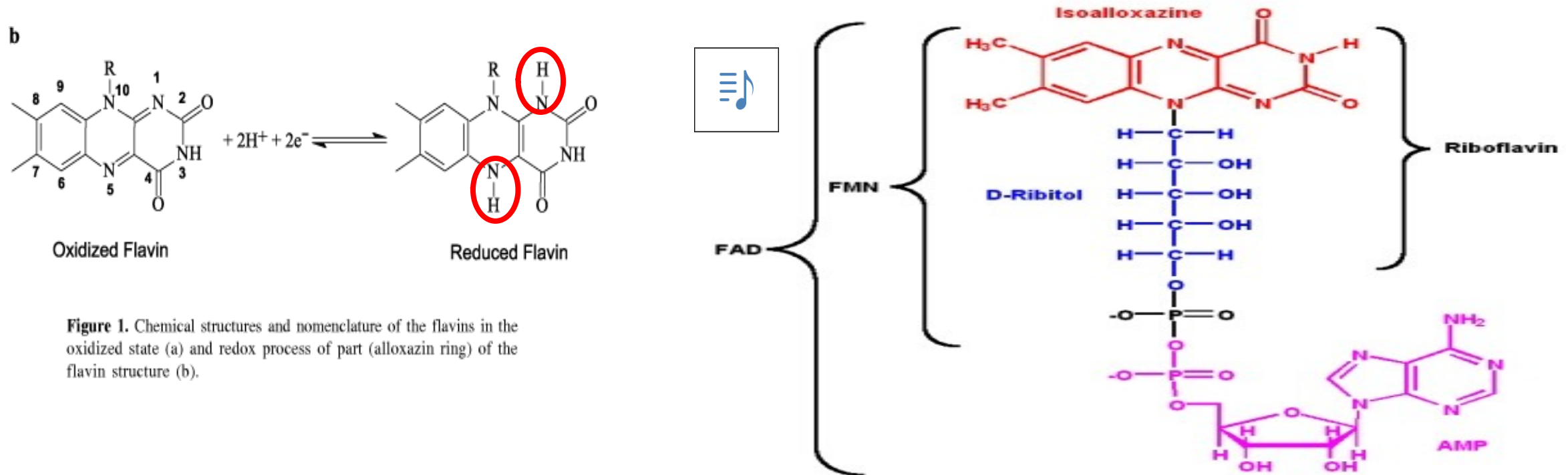
1- What is the suspected diagnosis?



Functions of Riboflavin vitamin (B2)



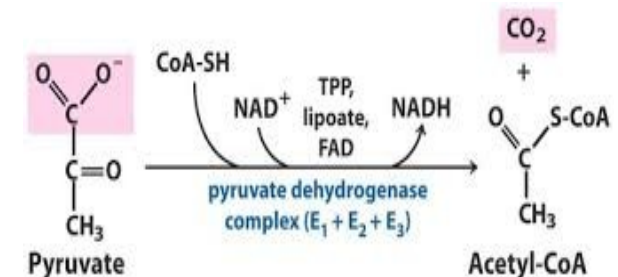
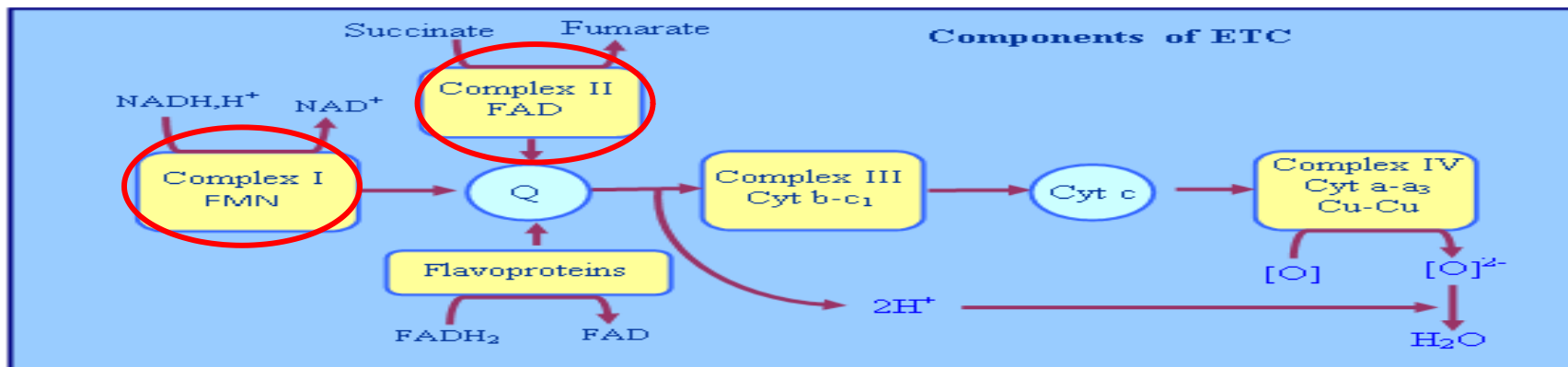
Active forms: flavin adenine dinucleotide (**FAD**) and flavin mononucleotide (**FMN**) which acts as hydrogen carrier *in oxidation-reduction reactions*



Functions of Riboflavin vitamin (B2)



Reactions catalyzed by FAD	Reactions catalyzed by FMN
Succinate dehydrogenase -1 (complex II in the ETC)	NADH dehydrogenase (complex -1 I in the ETC)
Glycine oxidase -2	L-amino acid oxidase -2
Alpha keto acids -3 dehydrogenase complex	



$$\Delta G'^{\circ} = -33.4 \text{ kJ/mol}$$

Deficiency Manifestations of B2

Affects mainly **skin and mucous membranes**



1. **Cheilosis** (swollen, fissured and congested lips)
2. **Angular stomatitis** (inflammation and fissures at the angles of the mouth)
3. **Glossitis** (magenta tongue)
4. **seborrheic dermatitis,**
5. **sun-shine eyes due to conjunctivitis.**



Angular
~~Stomatitis~~



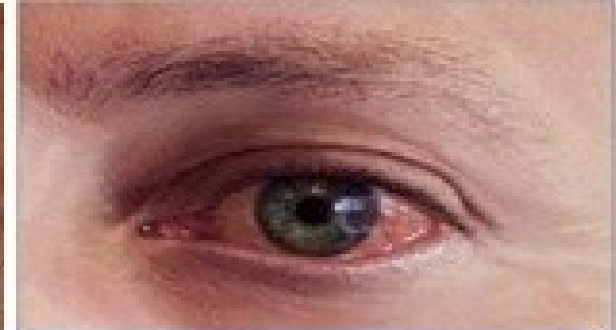
Cheilosis



Magenta Tongue



Seborrheic Dermatitis



Sun-shine Eye

FAD and FMN are the active forms of

- a. Vitamin B3
- b. Vitamin B6
- ☒ c. Vitamin B2
- d. Vitamin C
- e. Vitamin D





Niacin (nicotinic acid) (vitamin B3)

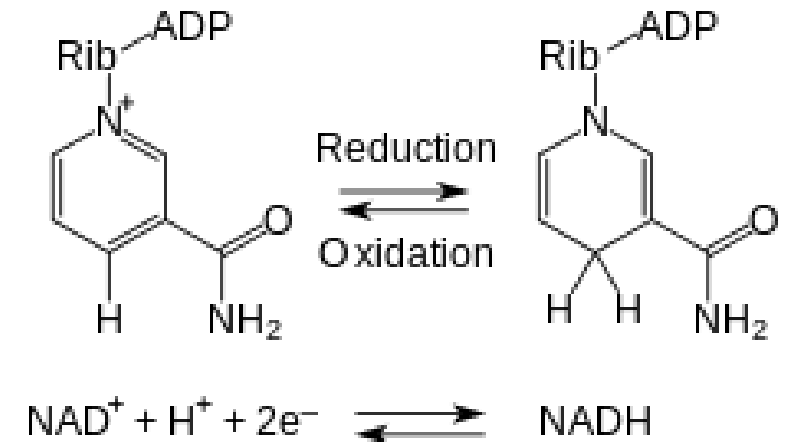
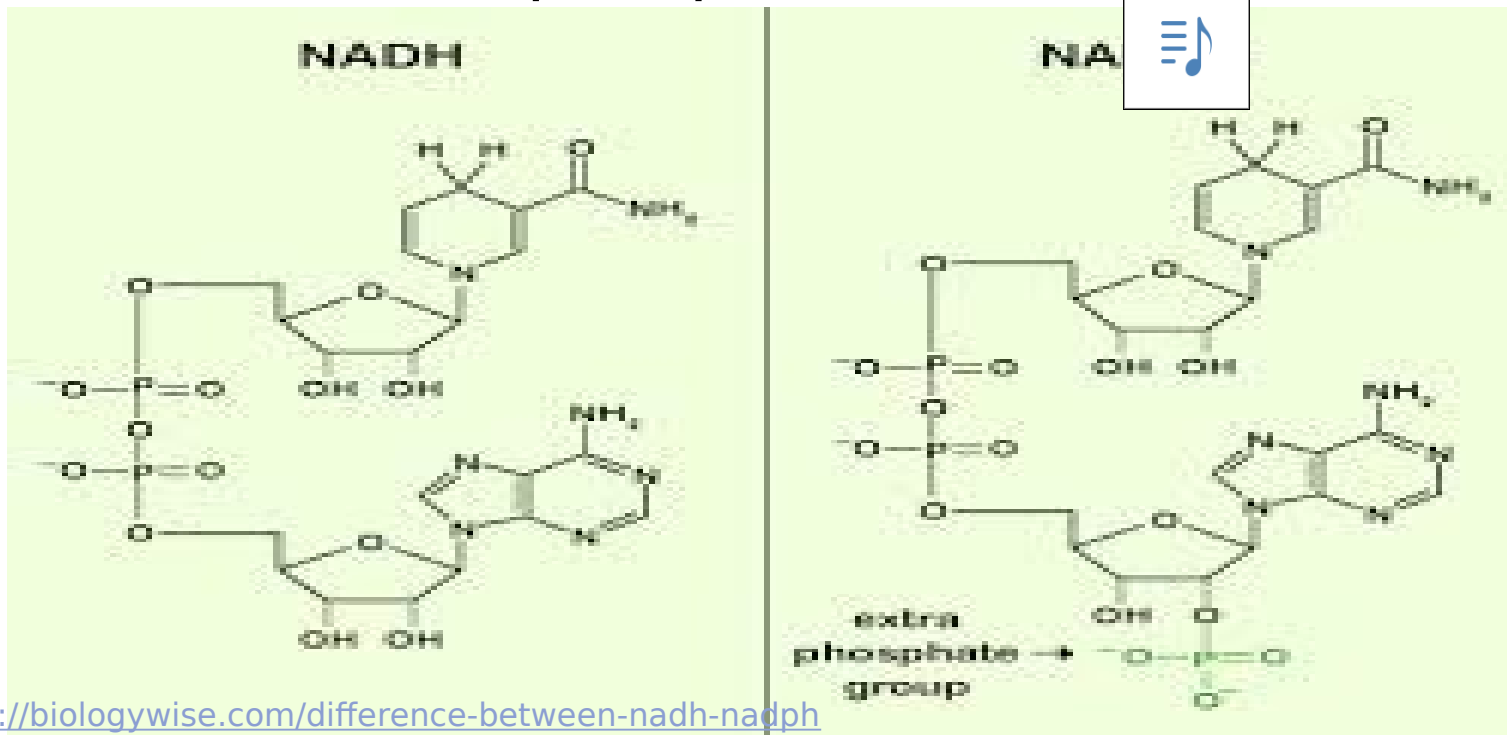
Niacin (nicotinic acid) (B₃)

Pellagra Preventive Factor (PPF)



Niacin is not strictly a vitamin since it can be synthesized from tryptophan (needs vitamin B6)

It is converted in the body into 2 hydrogen carriers (nicotinamide adenine dinucleotide (NAD) & nicotinamide adenine dinucleotide phosphate (NADP))



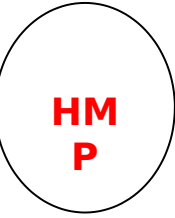
https://en.wikipedia.org/wiki/Nicotinamide_adenine_dinucleotide

NAD dependant enzymes

1. Glyceraldehydes 3-phosphate dehydrogenase
2. Lactate dehydrogenase
3. Pyruvate dehydrogenase complex
4. Mitochondrial isocitrate dehydrogenase.

NADP dependant enzymes

1. Glucose 6-phosphate dehydrogenase
2. 6-phosphogluconate dehydrogenase
3. Malic enzyme
4. Cytosolic isocitrate dehydrogenase
5. Glutathione reductase.



NADH generated is oxidized in the respiratory chain to generate 3ATP.

Niacin Deficiency (Pellagra)

Causes:

- i. Decrease Intake of Tryptophan & Niacin
- ii. Vitamin B₆ deficiency (decreased conversion of Tryptophan to niacin)
- iii. Carcinoid syndrome (shunting of tryptophan to serotonin synthesis)
- iv. Hartnup's disease (decreased absorption of tryptophan): it is a **Genetic condition** in which there is a defect of the membrane transport mechanism for tryptophan resulting in large losses as a result of renal reabsorption failure.

Explain on biochemical basis pellagra manifestations in Hartnup's disease

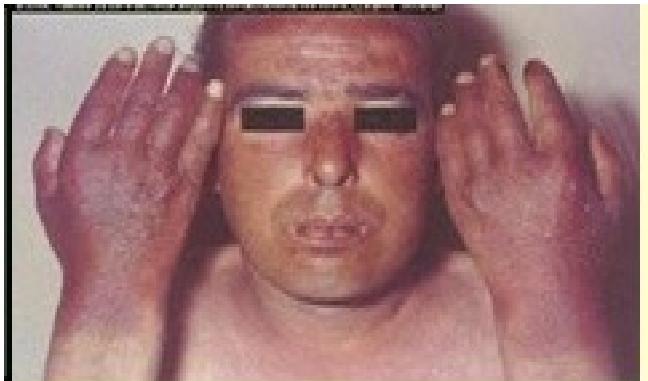


Manifestations: 3Ds

A.Dermatitis :rough scaly skin dark coloration of skin on the exposed parts of the body

B.Diarrhoea

C.Dementia: irritability, poor memory, peripheral neuritis and depression which end by dementia



Carcinoid tumour leads to deficiency of:



- a. Vitamin B6
- b. Vitamin B2
- c. Vitamin C
- d. Vitamin B3**
- e. Vitamin D



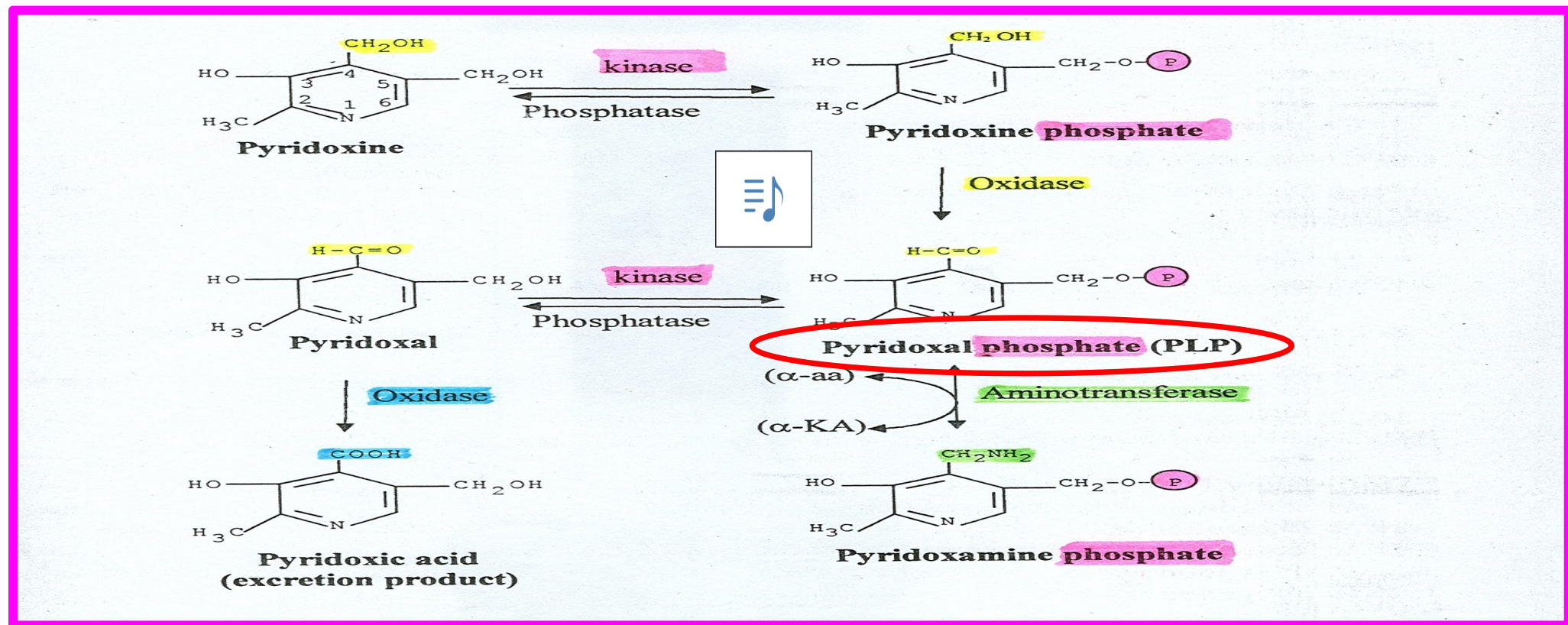


Pyridoxine (vitamin B6)

Pyridoxine vitamin (B6)



- Active form of pyridoxine is **pyridoxal phosphate (PLP)**.



<https://www.google.com.eg/url?sa=i&source=images&cd=&ved=2ahUKEwi2o8XmmPjAhXBAGMBHUUrC30QjRx6BAgBEAQ&url=https%3A%2F%2Fwww.studyandexam.com%2Fvitamin-b6.html&psig=AOvVaw2pnBouGp1ICFjds1YiFeDd&ust=1565522713484423>

Functions of PLP



A- acts as a coenzyme for many reactions in Protein metabolism:

- 1 - **Absorption** of amino acids and its uptake .
- 2- **Transamination reactions** e.g. ALT and AST.
- 3- **All decarboxylation reactions of amino acids** , e.g.

Explain
on a
biochemi
cal basis

i- Glutamate $\longrightarrow$ gamma aminobutyric acid (**GABA**)

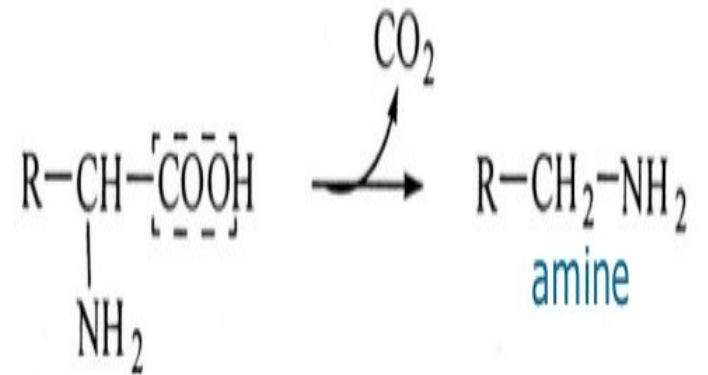
GABA is an **inhibitory neurotransmitter**, so in B₆ deficiency especially in children, epilepsy (**convulsions**) is common.

ii- Histidine $\longrightarrow$ histamine

iii- 5- Hydroxytryptophan $\longrightarrow$ serotonin

iv- Cysteine $\longrightarrow$ thioethanolamine and taurine

v- Serine $\longrightarrow$ ethanolamine



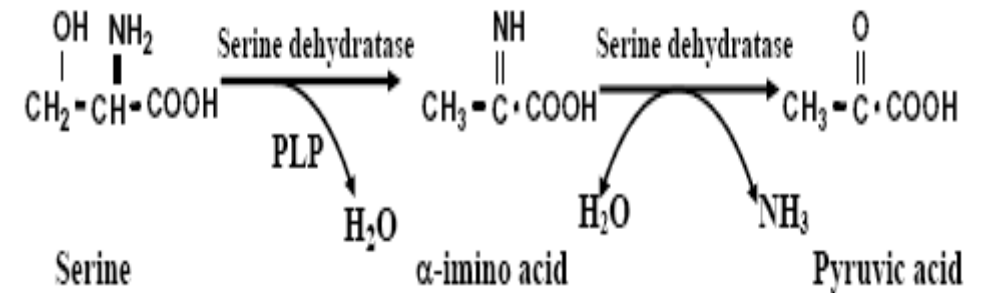
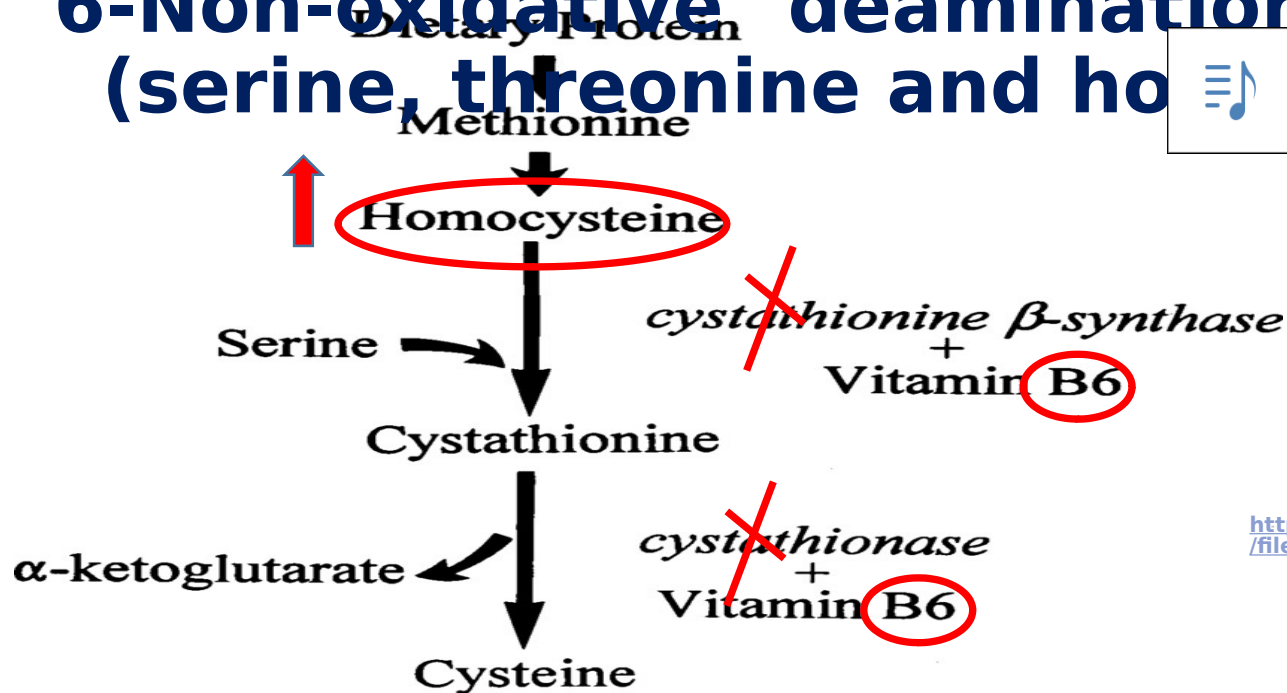
<https://www.slideshare.net/senchiy/amino-acids-metabolism-new-12281450>

4- Methionine and cysteine metabolism

In vitamin B6 deficiency, (**homocystinemia** → **hypertension**)

5-needed for conversion of **tryptophan to niacin**. So, in vitamin B6 deficiency **pellagra like manifestations appear**

6-Non-oxidative deamination of hydroxyamino acids (serine, threonine and homoserine)



http://osp.mans.edu.eg/medbiochem_mi/Cources/Biochemistry/2nd_year_medicine/Protein_metabolism/files/Lecture_02.htm

B-In lipid metabolism: coenzyme in the formation of sphingosine from palmitoyl-CoA and serine.

C- In heme biosynthesis: PLP acts as coenzyme for ALA synthase (key enzyme in heme biosynthesis). So, in B6 deficiency, **anemia** is common.

Explain on a biochemical basis

D- In carbohydrate metabolism:

Muscle glycogen phosphorylase has a pyridoxal phosphate at each catalytic site.

Functions of PLP



Protein metabolism

1
absorption of amino acids and its uptake

2-
Transamination reactions
e.g. ALT and AST.

3-
decarboxylation reactions of amino acids

4-
Methionine and cysteine metabolism

5-
conversion of tryptophan to niacin.

6-Non-oxidative deamination

4- **ALA synthase** in heme biosynthesis. So, in B6 deficiency, anemia is common.

6- coenzyme in the formation of **sphingosine** from palmitoyl-CoA and serine.

Muscle glycogen-7 phosphorylase has a pyridoxal phosphate at each catalytic site

Heme synthesis

Lipid metabolism

Carbohydrate metabolism

Deficiency of Vitamin B₆



Causes of deficiency:

- Pregnancy
- Alcoholics
- Oral contraceptives & Penicillamine
- Tuberculous patient treated with isoniazid (explained later)

Manifestations:

1-Hypochromic anemia due to impaired heme synthesis.

2-Neurological manifestations :



I. **Peripheral neuritis (stock and glove)** as PLP is involved in **sphingolipid synthesis**; so B₆ deficiency leads to demyelination of nerves.

II. **Convulsions**, particularly in children due to decreased formation of GABA.

3-**Pellagra like manifestations** due to decreased conversion of tryptophan to niacin.

4-**Homocysteinemia and homocystinuria**

Explain on a biochemical causes neurological manifestation in vitamin B6 deficiency?

Clinical indications for pyridoxine



• Tuberculosis

- Isoniazid, a drug commonly used to treat tuberculosis. It can induce vitamin B6 deficiency by forming an inactive derivative with PLP and inhibit endogenous synthesis.
- Dietary supplementation with B6 is needed to prevent B6 deficiency caused by Isoniazid .

• Morning sickness (Nausea & vomiting in the first 3 months (trimester) of pregnancy:



Vitamin B6 is needed for protein metabolism and neurotransmitter metabolism as decarboxylation of dopa to dopamine, decarboxylation of glutamic to GABA.

• Depression :

Through its role in creating neurotransmitters that regulate emotions, including serotonin, dopamine and gamma-aminobutyric acid

Explain on a biochemical basis



..... is essential for transamination reactions:



a. TPP

b. CoASH

c. PLP

d. FAD

e. Biotin



Key Points



- Vitamins are essential; their deficiency may lead to a characteristic disease.
- FAD and FMN are the active forms of vitamin B2 (riboflavin). They act as hydrogen carriers.
- NAD⁺ & NADP⁺ are the active forms of vitamin B3 (Niacin). Its deficiency leads to pellagra.
- PLP, the active form of vitamin B6, acts as a coenzyme for many reactions especially in protein metabolism. Its deficiency may lead to anemia, neurological manifestations, and pellagra like manifestations.

SUGGESTED TEXTBOOKS



- "Lippincott's Illustrated Reviews in Biochemistry" by P.C.Champe, R.A.Harvey and D.R.Ferrier
- "Harper's Biochemistry" by R.K.Murray, D.K.Granner, P.A. Mayes and V.W.Rodwell.
- Fundamentals of Clinical Chemistry (Tietz) Sixth
- "Textbook of Biochemistry with Clinical Correlations" by T.M.Devlin
- **www.namrata.co- *Biochemistry for medics***

Thank you